NEMS CLARKE EQUIPMENT

INSTRUCTION BOOKLET

13 March 1968

MODEL FSD-104A FOSTER-SEELEY DEMODULATOR

DESCRIPTION

The Model FSD-104A Foster-Seeley Demodulator is a front panel plug-in module designed for use with multi-range telemetry receivers. The FSD-104A contains a conventional Foster-Seeley fm demodulator and a bandpass filter which establishes the receiver's second i-f bandwidth. Physically locating the filter and the demodulator in the same mechanical package allows the performance of each demodulator to be optimized for the specific bandwidth.

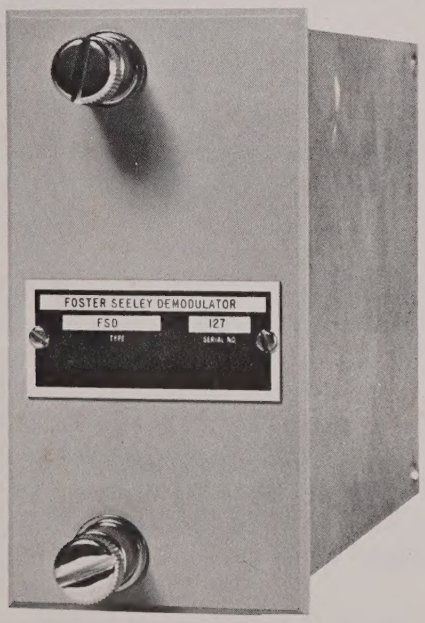


Figure 1. FSD-100A Series Foster-Seeley Demodulator

The demodulator is mounted on a chassis constructed of heavy gauge aluminum, which provides shielding when the module is plugged into the receiver. The demodulator is approximately 2-1/8 inches wide, 4-1/8 inches high, and 5-3/4 inches deep. The unit weighs approximately 1-1/2 pounds.

The performance specifications are listed below:

Filter:

Center Frequency	10.035 MHz.
Design Type	7 pole Butterworth LC.
Bandwidth	100 kHz ±10%, at 3 dB points.
Shape Factor	(60/6 dB ratio) 3.3.
3 dB Bandwidth Symmetry	1:1.2 maximum.
Insertion Loss	6 to 10 dB.

Demodulator:

Design Type	Foster-Seeley.
Linearity	3% maximum total harmonic distortion for peak-to-peak signal deviation of 50 kHz at a modulating frequency of 400 cps.
Output Level	3.0V p-p nominal for a peak deviation of 50 kHz.

INSTALLATION

The FSD-104A demodulator is a complete subassembly plug-in module. All electrical connections are made automatically as the unit is inserted into the receiver main chassis. There are no cables to be manually connected during installation, or disconnected during removal.

To install the demodulator, insert it through the appropriate opening in the receiver front panel; once in place, tighten the knurled thumb

To remove the demodulator, loosen the thumbscrew, then withdraw the unit from the receiver main chassis.

OPERATION

There are no operating controls incorporated into the FSD-104A. Consequently, there are no setup procedures.

The demodulator functions as an integral part of the receiver. Therefore the instruction manual for the receiver should be consulted for operating instructions.

PRINCIPLES OF OPERATION

The FSD-104A comprises a Foster-Seeley Discriminator and an i-f bandwidth filter. The two subassemblies are discussed separately in the following paragraphs. The schematic diagram, figure 7, should be referenced during the discussions.

IF Bandwidth Filter

The filter network is composed of a seven pole Butterworth LC network with a center frequency input of 10.035 MHz, and an i-f bandwidth of 100 kHz. The filter with its sharp skirt selectivity determines the overall receiver bandwidth.

The output of the First IF Amplifier and Second Mixer Module in the receiver is connected to the i-f bandwidth filter through A2 on P2. From A2-P2, the signal passes through a single stage amplifier (physically located inside the filter compartment).

The receiver is designed to tolerate a filter insertion loss of 8 (±2) dB. The filter circuit in the FSD-104A has an insertion loss of more than 8 dB. Thus, an amplifier is employed in place of the attenuator used in other modules.

The amplifier obtains -12.5 vdc through the module plug. Resistors R17 and R18 provide a fixed bias. R15 and R16 complete the emitter circuit. The base of Q3 is rf grounded by capacitor C2. The i-f signal is coupled capacitively through C1 to transistor Q3. Inductance L1 is tapped to match the output impedance of transistor Q3. This inductor is tuned with capacitors C3 and C44 and variable capacitor C4. Energy from this first resonant circuit or pole is capacitively coupled through C5 to the next resonant network. The coupling capacitances and the L to C ratio of seven resonant circuits vary to obtain the required maximally flat response. The output inductor L7 is tapped to produce a 50 ohm output impedance.

FM Demodulator

The output from the wideband limiter is connected to the FM demodulator through a coaxial cable to jack A3 of connector P2 and coupled capacitively to the base on input transistor Q1. Transformer T1 resonates the output capacitance of Q1, C23, and C24.

Diodes CR1 and CR2 are connected back to back and provide an additional stage of limiting. The signal to the base of transistor Q2 is divided down by capacitor C23 and C24 to prevent input capacitance variations from detuning the resonant circuit of T1. Transistor Q2 operates as an IF amplifier to drive the Foster-Seeley Discriminator.

The collector circuit of Q2 is resonated by transformer T2 and C26. Energy is coupled to the secondary of transformer T3 by means of capacitor C29, C32, and C33. In this demodulator, all coupling is capacitive. This permits independent control of both the center frequency tuning and the bandwidth.

Transformers T2 and T3 convert the FM signal to an AM signal so it can be demodulated in a conventional AM manner by diodes CR3 and CR4. The resonant circuit of T3 and capacitor C31 is damped by resistors R12 and R13. R12 and R13 also form the dc path for the diode current. Capacitor C34 acts as a bypass capacitance for any IF signal present on the video side of the rectifying diodes. The output of this demodulator is made available at P2-10 for application to the Emitter Follower module in the receiver.

MAINTENANCE

WARRANTY NOTICE

Replacement of any components soldered to a printed circuit board by other than DEI factory representatives voids all warranties; in the event of a part/module failure requiring the use of a soldering iron on a printed circuit board, the equipment must be returned to the factory for replacement or repair to maintain the warranty.

CAUTION

If factory affixed seals are broken, the warranty is voided.

The Model FSD-104A FM Demodulator is designed to give long and troublefree performance with a minimum of maintenance. During normal operation, no periodic adjustments are required; unnecessary adjustments should be avoided as they may degrade the performance of the unit. The FSD-104A should be kept clean, relatively dustfree, and in good mechanical condition. Lubrication is not required and should be avoided as damage to the unit could result.

Preventive Maintenance

The preventive maintenance for the FSD-104A consists of a monthly and an annual check which are given in the following paragraphs.

Monthly

The monthly preventive maintenance check consists of blowing out the dust from the interior of the unit using low pressure air and making a visual inspection checking:

a. Resistors for blistering, discoloration and other evidence of overheating.
b. Wiring for cut, cracked, or frayed insulation.
c. Machine screws and nuts for looseness.
d. Rear apron connectors for corrosion and looseness.
e. Finish, for scratches and bare spots.

Burned or discolored resistors, corroded plugs, and defective wiring should be replaced. When plugs or wiring have been replaced, refer to the schematic diagram in figure 7 to ensure that the proper connections have been made. Bare spots and scratches should be covered using any available touch-up paint.

Annual

The performance characteristics of the FSD-104A, as an integral part of the receiver, should be checked annually. With the FSD-104A demodulator installed in the receiver, check the overall performance of the receiver.

Corrective Maintenance

Corrective maintenance for the FSD-104A consists of troubleshooting, replacement of defective component(s), and, if necessary, realignment of the unit.

Troubleshooting

Knowledge of the principles of operation as given in preceding paragraphs and familiarity with the schematic diagram shown in figure 7 are necessary prior to troubleshooting the FSD-104A.

The first check should be to ensure the fault is located in the demodulator. To do this, ensure the correct inputs are being applied to the demodulator.

Once the fault has been isolated to the demodulator, signal tracking methods can be employed to locate the defective stage or stages. After repairs have been made, the alignment of the particular circuit should be checked.

Repair and Replacement

All electrical parts employed in the FSD-104A are considered non-repairable. A complete list of electrical parts is given herein. Component locations are shown in figures 2 and 3.

The demodulator subassembly comprises a pc card. The complete subassembly or individual components on the card may be replaced, as the situation demands. To replace the complete subassembly, disconnect the input and output cables, then remove the four screws holding the pc board in place.

Care should be exercised when replacing components on the pc board. The suggested procedure for removing components from the boards is given below; the procedure requires the following material and equipment.

Liquid soldering flux	1/8 inch, #18 AWG flat braid
Flux remover	Medium wattage soldering iron.

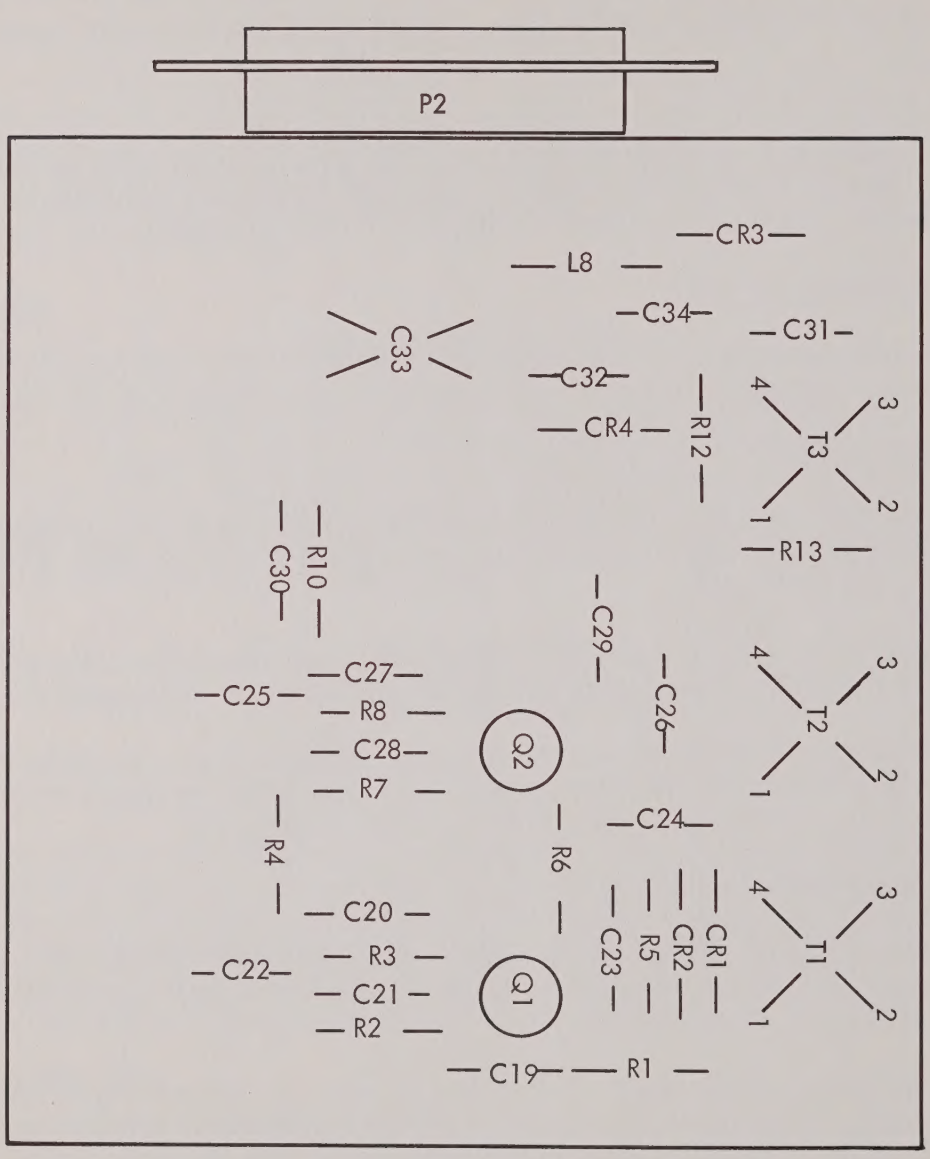


Figure 2. Demodulator, Component Location

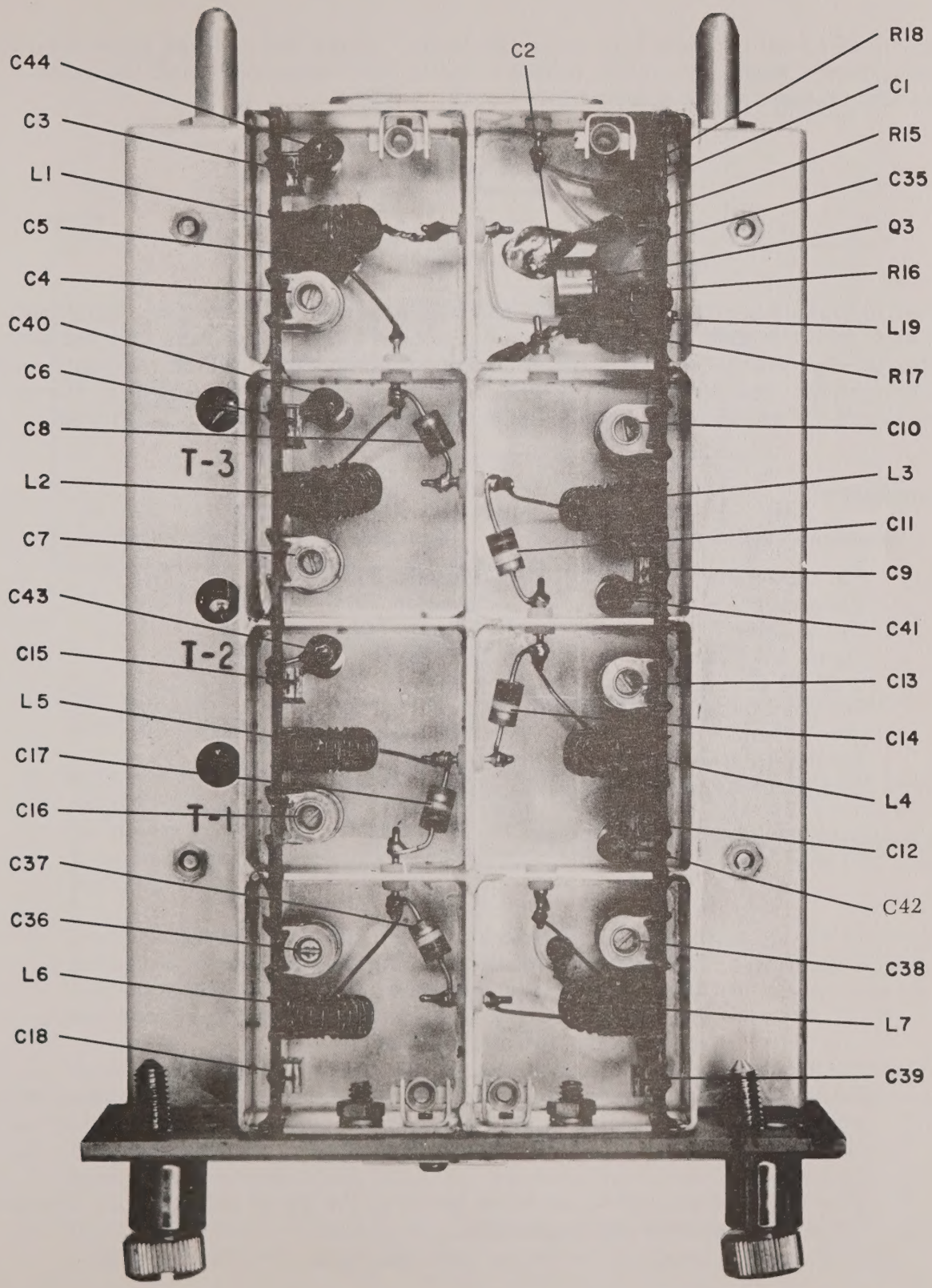


Figure 3. Bandwidth Filter, Component Location

Apply a thin coat of liquid flux to the flat braid. Place and hold the braid over the solder joint. Apply heat to the braid, directly over the solder joint; the braid will absorb most of the solder.

CAUTION

Do not heat the joint for long periods of time as excess heat may damage the circuit board.

After the major portion of the solder has been absorbed by the braid, apply heat directly to the solder joint and pry the component loose. Clean the affected area using the flux remover. Trim the replacement component leads to the same length as the original component leads. Position the replacement component on the circuit board and solder it in place. Clean the affected area with flux remover.

ALIGNMENT

Recommended Equipment:

FM Generator	Boonton 202J
Univerter	Boonton 207G
Sweep Generator	Jerrold 602
Signal Generator	HP 606A
6 dB 50 ohm Attenuator	
50 ohm Coaxial RF Detector	
Oscilloscope	Tektronix 130C
Electronic Counter	HP 5245L
High Impedance Diode Probe	

IF Bandpass Filter

NOTE

The frequency of the signal generator being used for a marker, in this case the HP 606A signal generator, must be set precisely at 10.035 MHz utilizing the electric counter.

a. Set up the test equipment as shown in figure 4 using short connecting cables wherever possible. The 50 ohm detector should remain connected to the output of the filter during the entire alignment.

b. Connect the high impedance diode probe to the top of inductor L1; connecting leads must be as short as possible.

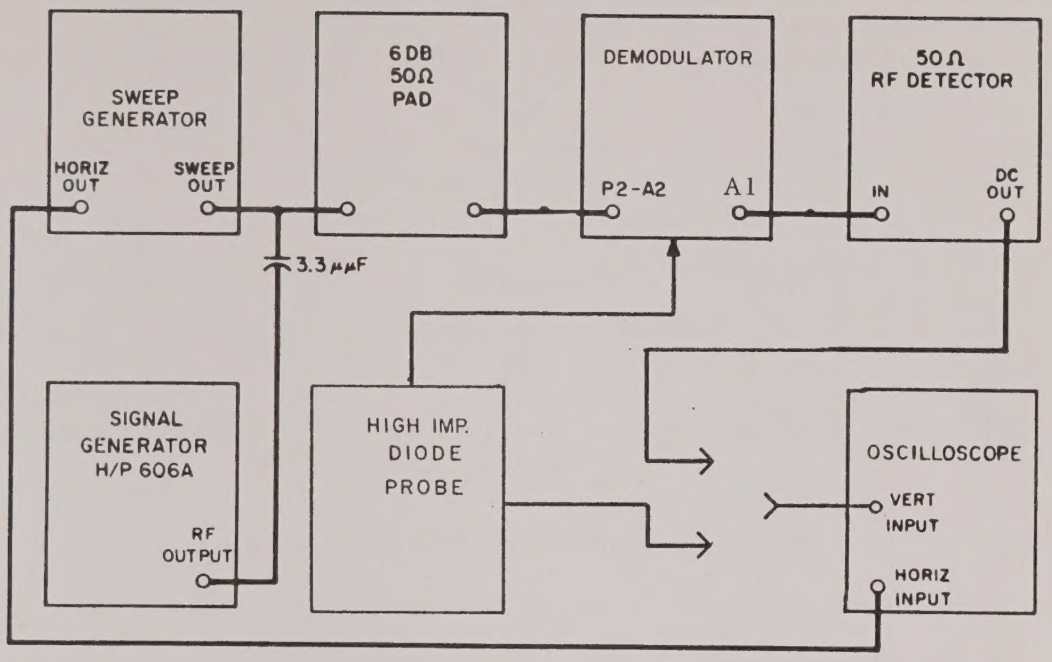


Figure 4. Alignment Procedure Test Set-Up

c. Short circuit the top of L2 to ground, using a very short cliplead, at the feedthru terminal.

d. Adjust a 10.035 MHz marker input so that a mark can be seen on the oscilloscope. Adjust variable capacitor C4 for a maximum response at 10.035 MHz, as shown on figure 5, response No. 1 (during the alignment procedure vary the amplitude and sweepwidth of the generator as necessary to provide the sharpest tuning).

e. Remove the short circuit from L2 and short circuit the top of L3 to ground. Adjust C7 for a minimum response at 10.035 MHz as shown in figure 5, response No. 2, (the high impedance diode probe is left in the first stage during the entire alignment procedure).

f. Remove the short circuit from L3 and short circuit L4. Adjust C10 for maximum response at 10.035 MHz, as shown in figure 5, response No. 3.

g. Remove the short circuit from L4 and short circuit L5. Adjust C13 for minimum response at 10.035 MHz, as shown in figure 5, response No. 4.

h. Remove the short circuit from L5 and short circuit L6. Adjust C16 for a maximum response at 10.035 MHz, as shown in figure 6, response No. 1.

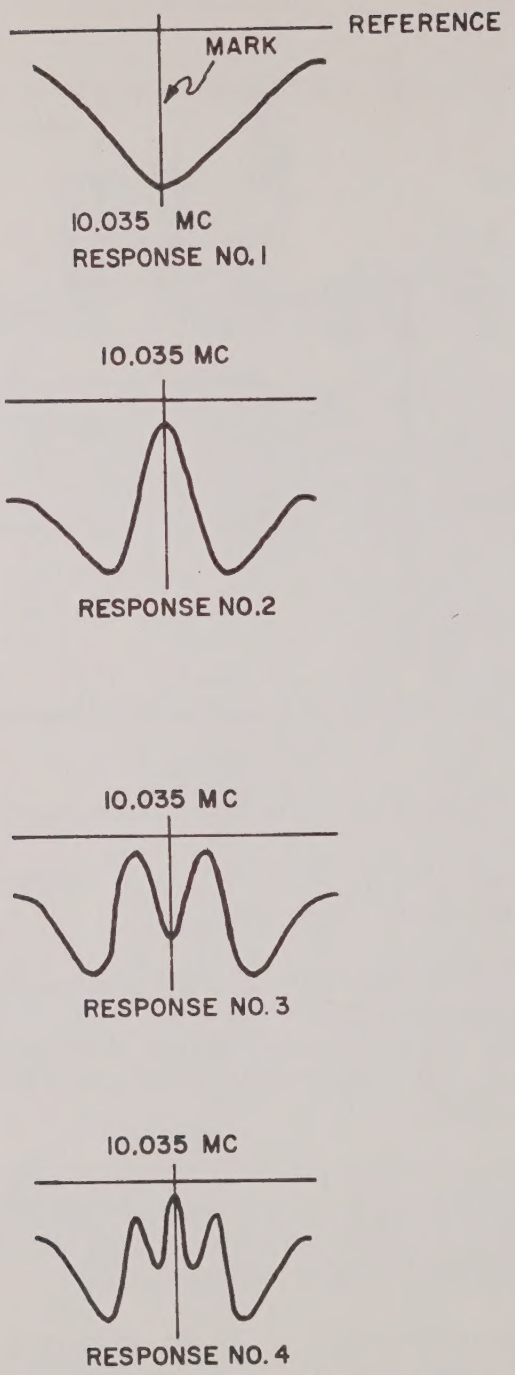
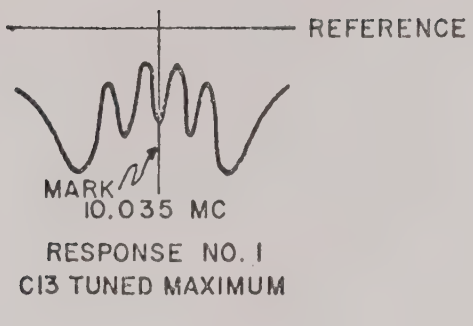
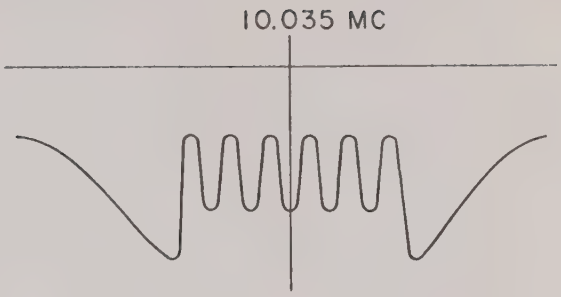


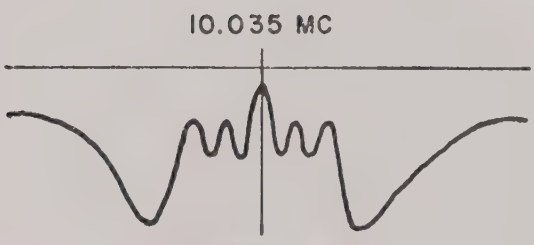
Figure 5. Oscilloscope Waveforms for FSD-104A Filter Alignment



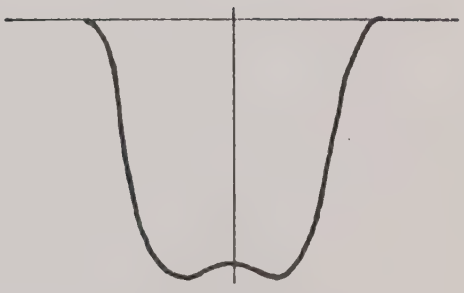
RESPONSE NO. 1
C13 TUNED MAXIMUM



RESPONSE NO. 3
C 36 TUNED MAXIMUM



RESPONSE NO. 2
C16 TUNED MINIMUM



10.035 MC
RESPONSE NO. 4
OVERALL RESPONSE

Figure 6. Oscilloscope Waveforms for Filter Alignment

i. Remove the short circuit from L6 and short circuit L7. Adjust C36 for minimum response at 10.035 MHz, as shown in figure 6, response No. 2.

j. Remove the short circuit from L7 and adjust variable capacitor C38 for a maximum response at 10.035 MHz, as shown in figure 6, response No. 3.

k. Remove the high impedance diode probe from the first stage and connect the oscilloscope to the 50 ohm detector to observe the overall filter response (figure 6, response No. 4). If the response is slightly unsymmetrical, a slight adjustment of tuning capacitor C4 and C38 should correct for this. If the overall response is very poor, the entire alignment procedure should be repeated being careful to adjust the maximum and minimum points precisely to 10.035 MHz.

Foster-Seeley Demodulator

a. Remove the demodulator plug-in from the receiver chassis and connect the module extension test cable from the demodulator to the receiver main chassis.

b. Connect the sweep generator to limiter module input J2.

c. Connect the oscilloscope horizontal amplifier to the sweep generator horizontal output and the oscilloscope vertical amplifier to emitter follower module input. This is on the base of Q1.

d. Adjust the sweep generator and the oscilloscope until an "S" curve appears on the oscilloscope trace. The generator should be near maximum output to ensure that limiter module is limiting.

e. Adjust T2, C33, and T3 for symmetrical "S" curve centered at 10.035 MHz utilizing the signal generator as a marker source.

f. T3 will control the center frequency of the "S" curve (zero crossover point) and T2 will generally control the linearity and symmetry of the curve and C33 will control bandwidth and center frequency.

g. Reduce the sweep generator signal level output until the amplitude of the "S" curve has been reduced to half and adjust T1 for a maximum output on the oscilloscope. (When the amplitude has been reduced, limiter module is no longer limiting.)

h. Apply an FM modulated signal with a peak deviation of 50 kHz to the First IF Amplifier and second converter module jack J2. Set the frequency accurately to 30 MHz. (10.035 MHz at the receiver Predetection output.)

i. Adjust the signal level until a pure signal output (no noise) appears on the oscilloscope connected to video output jack on the rear panel.

j. Adjust C33 if necessary to obtain a reading of 50 (±30%) on the receiver deviation meter.

k. Adjust T3 for 0V dc at pin 10 of P2 with 10.035 MHz at the predetection output. Adjust tuning meter control R14 on audio/metering module if necessary to obtain zero reading on tuning meter.

l. Reconnect the sweep generator in place of the signal at 30 MHz IF amplifier module J2 and readjust T2 as required for the most linear "S" curve.

ELECTRICAL PARTS LIST

IF BANDWIDTH FILTER, Reference figure 3

Reference Designation	Description
C1	Capacitor, ceramic, 0.01 uF +80-20%, 50V, Sprague 19C214
C2	Capacitor, ceramic, 0.01 uF +80-20%, 50V, Sprague 19C214
C3	Capacitor, 75 pF ±1%, 500V, Corning CYFM10C750F
C4	Capacitor, variable, 0.8 pF - 12 pF, 750V, JFD VCJ1542
C5	Capacitor, 1 pF ±10%, 500V, Quality Component Type QC
C6	Capacitor, 75 pF ±1%, 500V, Corning CYFM10C750F
C7	Capacitor, variable, 0.8 pF - 12 pF, 750V, JFD VCJ1542
C8	Capacitor, 0.75 pF ±10%, 500V, Quality Component Type QC
C9	Capacitor, 75 pF ±1%, 500V, Corning CYFM10C750F
C10	Capacitor, variable, 0.8 pF - 12 pF, 750V, JFD VCJ1542
C11	Capacitor, 1.2 pF ±10%, 500V, Qualtiy Component type QC
C12	Capacitor, 75 pF ±1%, 500V, Corning CYFM10C750F
C13	Capacitor, variable, 0.8 pF - 12 pF, 750V, JFD VCJ1542
C14	Capacitor, 1 pF ±10%, 500V, Quality Component Type QC
C15	Capacitor, 75 pF ±1%, 500V, Corning CYFM10C750F
C16	Capacitor, variable, 0.8 pF - 12 pF, 750V, JFD VCJ1542
C17	Capacitor, 1.5 pF ±10%, 500V, Quality Component Type QC
C35	Capacitor, ceramic, 0.01 uF, +80-20%, 50V, Sprague 19C214

IF Bandwidth Filter, continued

Reference Designation	Description
C36	Capacitor, variable, 0.8 pF - 12 pF, 750V, JFD VCJ1542
C37	Capacitor, 2.7 pF ±10%, 500V, Quality Component Type QC
C38	Capacitor, variable, 0.8 pF - 12 pF, 750V, JFD VCJ1542
C39	Capacitor, 100 pF ±1%, 500V, Corning CYFM10C101F
C40 through C44	Capacitor, ceramic, 24 pF ±2%, Erie CC22 UJ240G
L1	Inductor Assembly, NEMS-Clarke 102925-95
L2 through L6	Inductor Assembly, NEMS-Clarke 102925-97
L7	Inductor Assembly, NEMS-Clarke 102925-96
P2	Connector, plug, Cannon DBM13W3P, with 3 coaxial inserts, Cannon DM53740-5008
Q3	Transistor, 2N2218
R15	Resistor, composition, fixed, 240Ω ±5%, 1/4W, RC07GF241J
R16	Resistor, composition, fixed, 360Ω ±5%, 1/4W, RC07GF361J
R17	Resistor, composition, fixed, 5.1k ±5%, 1/4W, RC07GF512J
R18	Resistor, composition, fixed, 15k ±5%, 1/4W, RC07GF153J

FM DEMODULATOR, Reference figure 2

Reference Designation	Description
C19 through C22	Capacitor, ceramic, 0.01 uF, +80-20%, 50V, Sprague 19C214
C23	Capacitor, mica, 100 pF ±5%, 500V, Elmenco DM15F101J03

FM Demodulator, continued

Reference Designation	Description
C24	Capacitor, mica, 270 pF ±5%, 500V, Elmenco DM15E270J03
C25	Capacitor, ceramic, 0.01 uF, +80-20%, 50V, Sprague 19C214
C26	Capacitor, mica, 75 pF ±5%, 500V, Elmenco DM15E750J03
C27	Capacitor, ceramic, 0.01 uF, +80-20%, 50V, Sprague 19C214
C28	Capacitor, ceramic, 0.01 uF, +80-20%, 50V, Sprague 19C214
C29	Capacitor, mica, 100 pF ±5%, 500V, Elmenco DM15F101J03
C30	Capacitor, ceramic, 0.01 uF, +80-20%, 50V, Sprague 19C214
C31	Capacitor, mica, 75 pF ±5%, 500V, Elmenco DM15E750J03
C32	Capacitor, mica, 18 pF ±5%, 500V, Elmenco DM15E180J03
C33	Capacitor, variable, 0.8 pF - 12 pF, 750V, JFD VC31GW
C34	Capacitor, ceramic, 47 pF ±5%, 500V, CC25 CH470J
CR1 through CR4	Diode, Fairchild FD824 or 1N4305
L8	Choke, rf, 63 μH, Wilco 3063-15
P2	Connector, plug, Cannon DBM-13W3P
P2A3	Connector, plug, contact, termination, Cannon DM-53741-5000
Q1	Transistor, 2N3291
Q2	Transistor, 2N3291
R1	Resistor, composition, fixed, 10k ±5%, 1/2W, RC20GF103J
R2	Resistor, composition, fixed, 5.6k ±5%, 1/2W, RC20GF562J
R3	Resistor, composition, fixed, 560Ω ±5%, 1/2W, RC20GF561J
R4	Resistor, composition, fixed, 100Ω ±5%, 1/2W, RC20GF101J
R5	Resistor, composition, fixed, 3.3k ±5%, 1/2W, RC20GF332J

FM Demodulator, continued

Reference Designation	Description
R6	Resistor, composition, fixed, 10k ±5%, 1/2W, RC20GF103J
R7	Resistor, composition, fixed, 5.6k ±5%, 1/2W, RC20GF562J
R8	Resistor, composition, fixed, 560Ω ±5%, 1/2W, RC20GF561J
R10	Resistor, composition, fixed, 100Ω ±5%, 1/2W, RC20GF101J
R12	Resistor, composition, fixed, 5.6k ±5%, 1/2W, RC20GF562J
R13	Resistor, composition, fixed, 5.6k ±5%, 1/2W, RC20GF562J
T1	Transformer, NEMS-Clarke 101924-90
T2	Transformer, NEMS-Clarke 101924-90
T3	Transformer, NEMS-Clarke 101925-90

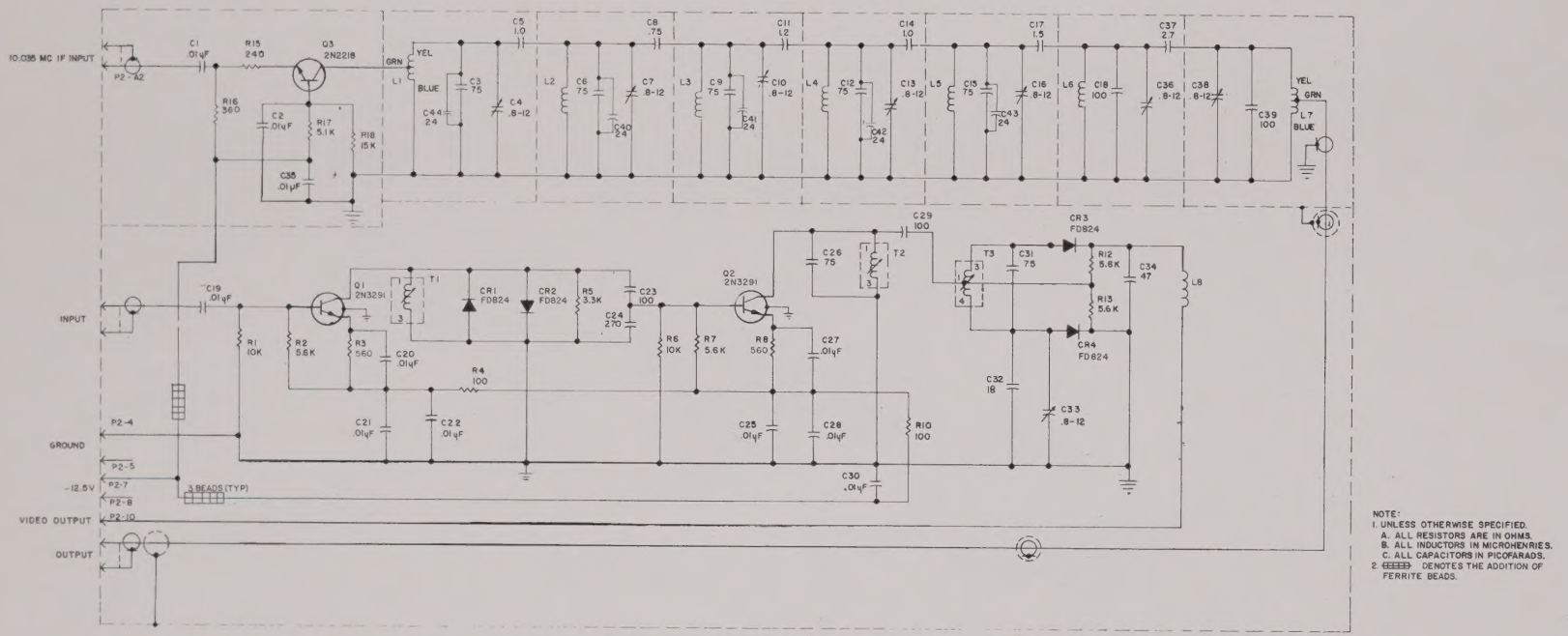


Figure 7. FSD-104A Foster-Seeley Demodulator, Schematic Diagram 300786E